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## THE VEGETATION OF THE HACKENSACK MARSH: A TYPICAL AMERICAN FEN

*By*
JOHN W. HARSHBERGER AND VINCENT G. BURNS

WAGNER FREE INSTITUTE OF SCIENCE
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# THE VEGETATION OF THE HACKENSACK MARSH: A TYPICAL AMERICAN FEN

By JOHN W. HARSHBERGER and VINCENT G. BURNS*

## INTRODUCTION (V. G. B.)

THE Hackensack River, which may be regarded as a branch of the Passaic, rises in the northeastern corner of the State of New Jersey, and drains a region of considerable extent lying along the west slopes of the Palisade Range. From the town of Hackensack south to the outlet in Newark Bay the river occupies a valley approximately four miles in width and eight miles in length, which is largely filled by a brackish tide-water marsh. On the west the marsh is separated from the valley of the Passaic by a long, low ridge of reddish-brown sandstone (Newark System of Triassic), and on the east a parallel ridge of igneous rock (Palisade Diabase of Triassic) separates it from the Hudson River. Outcroppings of the latter—igneous intrusion—are found in the center of the valley in the form of two large rock masses, known as Snake Hill and Little Snake Hill (Fig. 1). Owing to the scarcity of connected outcrops over the entire area of the Hackensack Valley, no definite stratigraphic succession of the rocks underlying the marsh has been determined up to the present time. However, it is stated in the Geologic Atlas of New Jersey, published in 1908, that the greater part of the Hackensack marsh is known to lie "in a deep depression excavated mainly in shales which have been reached by some of the wells." Numerous borings about Newark, Hackensack, and neighboring points have given information concerning the layers which occur above the underlying rock. Data obtained from records of these borings, in the Geologic Atlas of New Jersey (1908) and from Mr. Hewitt Crosby, Reclamation Engineer of New York City, make possible the following interpretations of the foundation of the marshes.

It is definitely known that the marsh is underlaid by a layer of Triassic red shale, because this rock has always been reached wherever deep borings have been made. That this shale constituted the main part of the exposed rock in the region of the marsh just prior to the Pleistocene Glaciation seems

* The separate parts of this contribution to botanic science are indicated by the initials of author contributing that part, viz., J. W. H. and V. G. B.

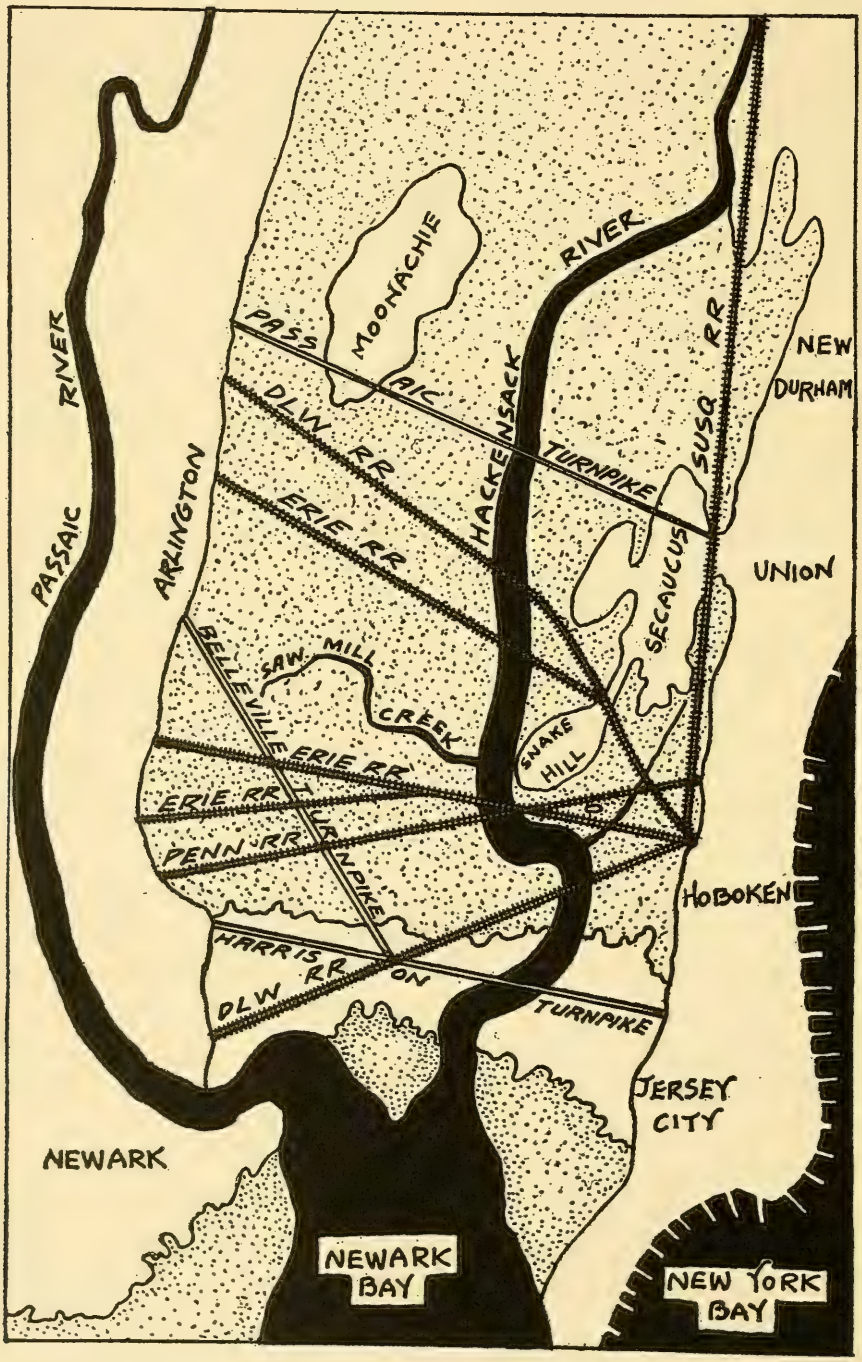


FIG. 1.
Sketch map of the Hackensack Marsh, New Jersey. Vincent G. Burns.

evident from the fact that at the present time the glacial drift lies just above it. The drift is mixed with and covered by a deep stratum of laminated clay which contains gravel, boulders, and calcareous nodules in abundance. The composition of the clay and its position just above the glacial drift lead one to believe that it was deposited in standing water left by the retreating Pleistocene ice-sheet. The thickness of this clay stratum varies from 85 to 250 feet, the greater thicknesses being due to the presence of large quantities of drift.

Just above the laminated clay occurs a thin layer of alternating sand and yellow loam, averaging 2 to 3 feet in thickness. The loam corresponds exactly to that found exposed at many places adjoining the Hackensack marsh, and it is quite probable that the loam, now covered, was at one time continuous with that exposed in neighboring regions. The presence of the sand at different places is puzzling. It may be the remains of the old sandy sea-beach upon which the present marsh was built by the action of the tide, but this is not at all certain (Fig. 2).

Above the shallow layer of sand and loam there is a much deeper stratum of black, soggy muck which ranges from a depth of only 1 foot to 70 feet in some places. This is chiefly a mixture of dark silt, organic matter, water, and gases ($CH_4$, $CO_2$, $H_2S$, etc.), and probably owes its origin to long action of the tidal water in depositing silt and also to the accumulation of plant remains.

Perhaps, also, after the final withdrawal of the great ice-sheet from the glaciated regions of America, a shallow inland bay or arm of the sea was left where the Hackensack marsh now is. The flat margins were, no doubt, wet enough to support marsh vegetation, and as the time went on this vegetation came to fill the bay, leaving open the tortuous tidal channels, or creeks, which intersect the surface of the present marsh. The fact that stumps with roots of the white cedar, *Chamæcyparis thyoides*, are found imbedded in the muck indicates (Fig. 3) that in recent times the marsh surface in places was above tide-water and covered with groves of trees,* and for the reason that this tree has been reported near Newark by W. M. Wolfe. The obliteration of most of this acid swamp was brought about probably either by a resinking of the shore

* Cf. somewhat similar conditions of the encroachment of salt marshes on Chamæcyparis trees in Massachusetts, viz., *Bartlett, Harley H.:* The Submarine Chamæcyparis Bog at Woods Hole, Massachusetts, Rhodora 11: 221–235, December, 1909.

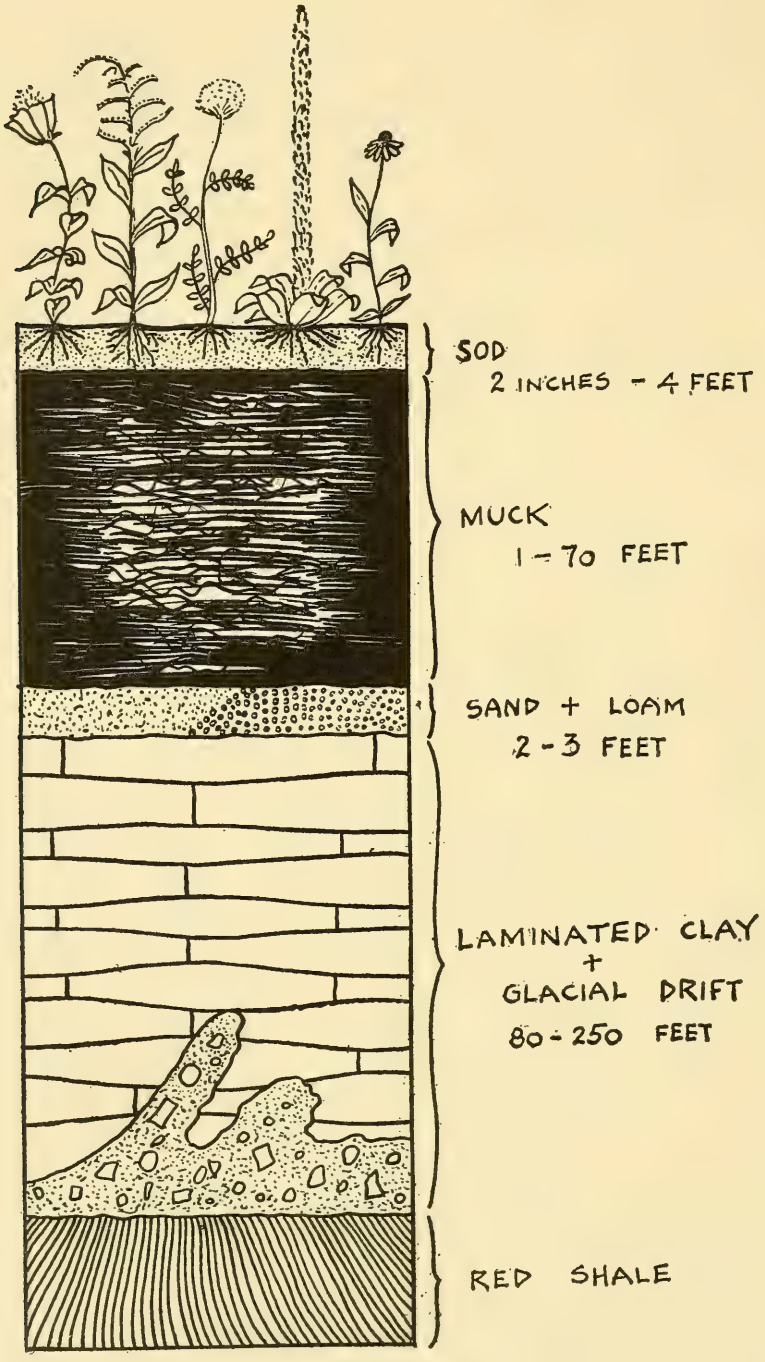


FIG. 2.
Cross-section of the soil layers of the Hackensack Marsh. Vincent G. Burns.

line or by a change in the tidal levels, which introduced brackish or saline conditions again.

Overlying the muck and covering the marsh surface is a dense mat of roots, plant remains, and decaying organic material, which forms a sod ranging from 2 inches to 4 feet in thickness (Fig. 2). This sod, when dry, is extremely hard and compact, and for this reason is used advantageously in dike-building.

## COMPARATIVE STUDY OF FEN VEGETATION (J. W. H.)

Ecologic research has reached such a stage in America that it is profitable to compare the phytogeographic formations of North America with similar ones of other lands. This comparative study is necessary in order to give us clearer views of the causes underlying the distribution of plants with respect to their habitat conditions. The author has recently paid considerable attention to this phase of ecologic research, and has printed one paper dealing with "American Heaths and Pine Heaths." He has had accepted for publication another comparative study of "Alpine Fell-fields in Eastern North America," and he has the photographs and material assembled for another contribution on "The Influence of Slope Exposure in Plant Distribution." The present account of the ecology of the Hackensack Marsh, written in conjunction with the floristic studies of Vincent G. Burns, is a fourth contribution to such comparative ecology.

The vegetation of the Hackensack Marsh constitutes a number of plant formations, two of the most important being the salt marsh formation and the fresh-water marsh formation. In England the type of fresh-water marsh represented in America by the part of the Hackensack Meadow controlled by fresh water is called a fen. It is important, as ecologists, for us to have clear concepts of the character of the units of vegetation in this and other countries before we attempt to describe them. This desideratum is reached in part by comparing the words used in different places for the same phytogeographic formation. Sometimes the popular usage runs parallel with the exact scientific application of the name. At other times it does not become applicable. The terms "marsh" and "swamp," in common language, are frequently used interchangeably. But phytogeographically speaking, marshes and swamps are quite different, physiognomically and floristically. The two terms "moor" and "fen" are often confused in England. A distinction must be made

between them. There are great tracts of peat laid down in the upper part of old estuaries, and around fresh-water lakes, which are called fens. Such terms as the French "Le Marais immerge," "Le Marais lacustre," the Bohemian "Slating," are akin to that of fen. The soil of a fen is a muck, rather than a peat, fed by telluric water with an alkaline reaction and relatively rich in mineral salts. This character of the soil has a profound effect on the vegetation.

## ENGLISH FENS

Considerable attention has been given of late years, since the ecologic awakenment of English botanists, to the vegetation of fens or reed swamps (reed marshes). One of the earliest accounts is by Yapp, on Wicken Fen, not far from Cambridge, in the region of the Wash.* The dominant herbaceous plants of this fenland are tall, reedy grasses, sedges, and rushes growing out of the wet muck. The raised parts of the fen can be distinguished at a distance by the plants growing on them. Thus, toward the end of July many of these banks are easily recognized by the masses of flowering *Spiræa Ulmaria* and associated species. Most of the plants that grow in the wet have creeping stems and stiff pointed shoots that can easily force their way up through the overlying muck. The roots of fen plants are placed more or less horizontally. The stratification in the vegetation of this marsh has been described in a later paper by Yapp, where emphasis is placed upon the fairly uniform facies of the vegetation and upon the different types of plants which enter into competition in the marshland.

Marietta Pallis furnishes a chapter in the "Types of British Vegetation" (1911: 214–234) on the fenlands of the Broads in the inner valleys of East Norfolk and East Suffolk. The Bure valley fen shows in summer a dense growth of grasses and sedges, such as *Phragmites communis*, *Molinia cærulea*, *Cladium Mariscus*, while the Yare valley fen at the same season of the year is a wild flower garden forming a different type of marshland. The Bure fen has only one species dominant, viz., *Phragmites communis*. Some of the fenland is characterized by the presence of trees and shrubs, which form the fen thickets, or carr.

Moss† emphasizes the chemical character of the soil as of importance for

* *Yapp, R. H.:* Sketches of Vegetation at Home and Abroad: IV: Wicken Fen. The New Phytologist, VII: 61–81, Feb. and March, 1908; Annals of Botany, XXIII: 275–319, Apr., 1909.

† *Moss, C. E.:* Vegetation of the Peak District, 1913: 168–171; Jour. of Ecol., VI: 53–74.

the peaty tracts of eastern England, which are characterized by alkaline waters, are spoken of usually by the local inhabitants as "black fens," or simply fens characterized by alkaline waters and by a high, soluble mineral content—especially by a high lime content. Accordingly, the vegetation of acidic peat may be said to belong to the moor formation, and that of the alkaline peat (muck) to the fen formation. The lists of plants for the two formations bring out in a marked degree these fundamental differences.

The aquatic and marsh vegetation of Esthwaite Water has been investigated recently by W. H. Pearsall,* who shows that the conditions of sedimentation influence the character of the associations. The reed swamps of the area of rapid sedimentation are peculiar in the absence of *Scirpus lacustris*, the presence of *Typha latifolia*, and the abundance of herbaceous species. He describes the mixed fen associes, which succeed reed swamp, as also the vegetation of the areas of moderate and slow sedimentation.

## FENS OF SWITZERLAND

For Switzerland, Früh and Schröter, in a monumental contribution, describe the flachmoor (reed marshes) of that country. They recognize a number of different types which owe their character to the plants which are associated. The roseau (Fr.), cannetta (Ital.), reed (Engl.), is the tallest and most abundant constituent of the fens of Switzerland. Its rhizomes spread horizontally considerable distances, forming a mat which binds the mud and slimy ooze into a rather firm mass. It contributes largely to the formation of the muck. The nodes of the creeping stem give rise to upright halms and roots. In such Swiss lakes as Lake Zug, there are scattered areas of *Phragmites communis* along the lake shores. Here it is associated with *Scirpus lacustris*, which is codominant with it. The width of the areas where these two plants are found depends on the depth of the water, which is shallow, especially along the west shores of the lake.

## PAPYRUS MARSHES IN SICILY

Near Syracuse in Sicily are two small rivers, the Anapo and the Ciani, which are characterized by growths of the papyrus (*Cyperus Papyrus*), the physiognomy of which resembles that of the fenlands of England and elsewhere, and in the broad sense the papyrus marsh may be included in the fen-

* *Pearsall, W. H.:* Jour. of Ecol., VI: 75–83, March, 1908.

land formations. The halms of this classic plant of Egypt reach a height of over 3 meters. Associated with the papyrus is the Spanish reed (*Arundo Donax*), the largest grass of Europe.

## REED MARSHES OF CENTRAL AND EASTERN EUROPE

Reed marshes are found in Saxony in several facies, one of which corresponds with the fen formation of England. The reed marshes of the Carpathian region of Europe occur in the Hungarian Plain, along the streams, and similar marshes exist in Illyria.

The Plav of Rumania, according to Miss Pallis,* is a floating fen formed almost entirely of living reed, *Phragmites communis β flavescens*. There are three more or less well-marked growth stages of the reed grass, namely: the open, the closed reed, and, in deep waters, Plav. The open reed marsh is the stage at which the growth of the reed shoots is as yet sparse along the edge of the lake or a stream, and the plants are fixed. Closed reed develops from open reed marsh automatically, and in time becomes Plav. Much soil is held by individual tussocks and by closely growing assemblages of tussocks. Plav, when newly detached, does not differ from closed reed marsh, except in that it floats.

One plant, *Typha angustata*, competes successfully with the reed in the delta of the Danube River, though it probably never supplants the reed absolutely, but merely inhibits its growth for a time. In the delta, *Phragmites* invades deeper water than *Typha*, hence it is only in shallow water that they enter into competition. *Cladium Mariscus* also is found in the Danube fens.

## ASIATIC FENLAND

In central Asia, *Phragmites communis* is found about nearly all of the rivers and lakes. The fens of eastern Turkestan, as at Kerija Darja, are the refuge places for the wild birds and wild pigs of that country. About Lop Nor, a lake in Chinese Turkestan, which is undergoing desiccation and is only a few feet deep, there are unprecedented growths of this reed grass, which, arching over the open channels of water, form tunnel-like passages for the movement of the native boats. Reed marshes are found not uncommonly in China (west of Shanghai), in Japan, about lakes Biwa and Chuzen.

* *Pallis, Marietta:* Structure and History of Plav: The Floating Fen of the Delta of the Danube. Journ. Linn. Soc., Botany, XLIII: 233–290, with plates and map.

## FENS OF AFRICA

Typical fen vegetation, with *Phragmites communis* prominent, is found in Africa about Lake N'gami, at least 6 to 7 kilometers broad, and in Togoland, also about Lake Victoria Nyanza. The vleys of South Africa are characterized by broad bands of *Juncus maritimus*, associated with the two South African cattails, *Typha australis* and *T. capensis*, while *Phragmites communis*, which plays a prominent rôle in other parts of Africa, is sparingly found, or entirely replaced by *Cladium Mariscus*, associated with the calla-lily, *Zantedeschia æthiopica*, which, with its white spathes, enlivens the South African fenland in winter, while in summer water-lilies in flower are conspicuous in the open places of the reed marshes. Vleys (Vleis) are found in South Africa, according to Bews,* wherever a depression in the ground checks drainage, such areas being known as "flushes." Few cover more than an area or two of ground. The vegetation varies—(1) according to the amount of water present, and (2) according to the degree of stagnation of the water.

## SUDD VEGETATION

Much has been written about the vegetation of the marshes of the Upper White Nile,† where vast masses of floating plants are moved hither and thither and block the waterways by forming dams (Arab, "sudd") across them. The mouth of the Bahr el Jebel, near Lake No and 627 miles above Khartoum, may be taken as the northern gate of the Sudd region—a vast country of marshes. The chief sudd-formers are *Cyperus Papyrus*, *Panicum pyramidale*, *Phragmites communis*, *Typha australis;* between them, as floating plants, occur the water-soldier, *Pistia Stratiotes*, *Azolla nilotica*, while the mass of plants forming the Papyrus fringe are bound together by numerous twiners and climbers. Toward Hillet en Nuer the banks are better defined and the papyrus is replaced by *Phragmites communis*, while *Panicum pyramidale*, called "Om-Suf," or "mother-of-wool," by the Arabs, on account of the irritant hairs at the base of the leaves, has the faculty of growing both in shallower and deeper water than the Papyrus, and not only occupies the land which is uncovered at low Nile, but forms a fringe in front of the Papyrus in the bed of the channel.

* *Bews, J. W.:* The Vegetation of Natal. Annals of the Natal Museum, II, Pt. 3: 320, May, 1912; Types of Vegetation in South Africa. Journ. of Ecol., IV: 147, Dec., 1916.

† *Brown, A. F.:* Some notes on the "Sudd" Formation of the Upper Nile. Journ. Linn. Soc., Botany, XXXVII: 51, 1904–1906.

## NORTH AMERICAN FENS

The American counterparts of the fen formation of England and other parts of the world have been studied in a number of localities, but we lack ecologic details for a large number of areas of marsh which belong to this category. About the head of Cayuga Lake, in Central New York State, is found Renwick Marsh, near Ithaca. The largest association of plants in this marsh consists of two predominating species of cattail, *Typha latifolia* and *T. angustifolia*, with the former more abundant. The two plants seldom mingle and are associated with few other plants. The species of *Typha* reach a height of 8 to 9 feet, and the growth in height is completed by the latter part of June or early July. This association furnishes the optimum conditions for certain birds. Such are the red-winged blackbirds,* coots, Florida gallinules, and the least bittern.

Skokie Marsh is associated with Skokie Stream along the west side of Lake Michigan in Illinois. The reed-marsh association is the principal one of the marsh. Within the associations of *Nymphœa* and *Castalia* almost pure growths of *Typha latifolia*, *Sparganium eurycarpum*, *Scirpus fluviatilis*, *S. validus* occur, associated with scattering plants of *Sagittaria latifolia*, *Sium cicutæfolium*, *Dulichium arundinaceum*, and *Decodon verticillatum*. In certain parts of the reed marsh, at stations slightly less hydrophytic, *Phragmites communis* grows. Elsewhere there are scattered patches of *Iris versicolor* and *Acorus calamus*.

Sherff† has studied in a detailed manner and has made careful drawings of the under surface stems and roots of the typical marsh plants which come into competition. He finds that two or more species may be associated harmoniously, because—(1) their subterranean stems may be at different depths; (2) their roots may thus be produced at different depths; (3) even where the roots are produced at the same depth, they may make unlike demands on the soil.

Wild rice, *Zizania aquatica*, is a tall-growing marsh grass found in especially pure growths in the ponds and lakes characteristic of Wisconsin and Minnesota, where the *falle avoine* has been from the earliest times gathered

* *Allen, Arthur:* The Red-winged Blackbird: A Study in the Ecology of a Cattail Marsh. Proc. Linn. Soc. of New York, 1911–13: 43–128.

† *Sherff, Earl E.:* The Vegetation of Skokie Marsh. Bot. Gaz., LIII: 415–435, May, 1912.

by the Indian for the nutritious grains.* The physiognomy of these marshes, when viewed from a distance, is that of the typical reed marsh, and frequently, as will be shown subsequently, *Zizania aquatica* is associated with the typical fen plants and can with propriety be included with them.

Typical fens are found in two places in California. Klamath Lake is situated in northeastern California, on the Oregon boundary line. Its shallow water permits a great growth of tule, *Scirpus lacustris* var. *occidentalis*, which has stout creeping root-stocks and triquetrous stems, 2 to 5 feet tall. Rushes grow with the tule, and these plants together fringe the lake shore, in places expanding to a width of several miles. They also form islands varying in size from a few square yards to many acres in extent.†

The most extensive tract of fens on the Pacific coast follows the course of the Sacramento River for a distance of 150 miles on either side. Here *Scirpus lacustris* var. *occidentalis* chokes the marshland, associated with *Scirpus tatora*. Islands occur, formed of muck, and they are separated from each other by tortuous channels. Annuals here are generally 4 to 6 feet in height, and plants 8 to 12 inches high in dry soil here double their size.

The Everglades of Florida is an immense grassy marsh, or fen, covered in the wet season—June to November—with water to an average depth of 26 inches, stretching on all sides to the horizon, and relieved in some places by clumps of bushes or low trees (carr), and characterized by lagoons, channels, or slues of open water, or filled with various aquatic plants. It extends south toward Cape Sable, from the southern end of Lake Okeechobee. The soil is a black muck (2.5 to 10 feet deep), overlying the limestone rocks which form the bottom and sides of the basin in which the fenland occurs. The whole area is covered with a rank growth of a coarse sedge, 8 to 10 feet tall, having leaves with a fine edge, like a saw, hence the common name.‡ The saw-grass, *Cladium effusum*, arises from a root-stock with matted roots. It forms exclusive growth of such density as to become impenetrable, but with open stretches of clear water, covered at places with water-lilies and pickerel weed. Islands of bushes and trees (English carr) are scattered over the sur-

* *Jenks, Albert E.:* The Wild-rice Gatherers of the Upper Lakes. Report Bureau of American Ethnology, 19, pt. 2: 1019–1133 (1897–98).

† *Chapman, Frank M.:* The Habitat Bird Group, Guide Leaflet No. 28, American Museum of Natural History, Feb., 1909, pages 38 and 39.

‡ *Harshberger, John W.:* The Vegetation of South Florida. Trans. Wagner Institute, VII, Pt. 3: 155–166, Oct., 1914.

face of the saw-grass marsh (saw-grass fen). The Everglades, covering an area of 4000 square miles, or 2,560,000 acres, is the largest fresh-water marsh (fen) in North America, lacking the typical fen plants of other parts of the world, but making up in physiognomic aspect for the absence of such plants as *Phragmites communis*, *Typha latifolia*, and other plants by the presence of other grasses and sedges of similar botanic aspect.

## HACKENSACK MARSH

The traveler between Philadelphia and New York, and the New York commuter who lives in New Jersey, see a great stretch of green flatland, with here and there the top of a fisherman's cabin, or the black mast of a catboat above the cattails and reed grasses over seven feet tall. Great factories are ever reaching on these marshes from all sides, and railroads cut them up into smaller and smaller areas of undisturbed vegetation. From a distance there is no trace nor sign of the many little hammocks that are found in the marsh, nor of the tidal creeks and estuaries which run in many directions. All that is noticeable in this general view is the unbroken verdure of the tall, reed-like plants, continually billowed by the passing breeze (Fig. 5).

The vegetation of the Hackensack fen may be divided into three formations, viz., the salt-marsh formation, the fresh-water marsh (fen) formation (Figs. 4, 5), and the marsh thicket (carr) formation (Figs. 7, 13). A bog formation (not studied) probably exists in the northern part of the region. Its investigation would probably give interesting details as to the succession of vegetation in the marshes.

These associations are well characterized, and their geographic location depends on the location of the marsh with reference to salt water, the highland on three sides of the marshy region, and on the direction of the fresh-water streams which run across the lowlands.

Salt Marsh Formation.—The natural undisturbed surface of the salt marsh of the Hackensack Meadow is fairly uniform in character. It is found at the mouths of the creeks and rivers which intersect the region, and around the margins of the lagoons and estuaries, forming extensions landward of Newark Bay. The influence of salt water is felt some distance above Newark Bay, and the tidal channels permit the entrance of sea water, so that

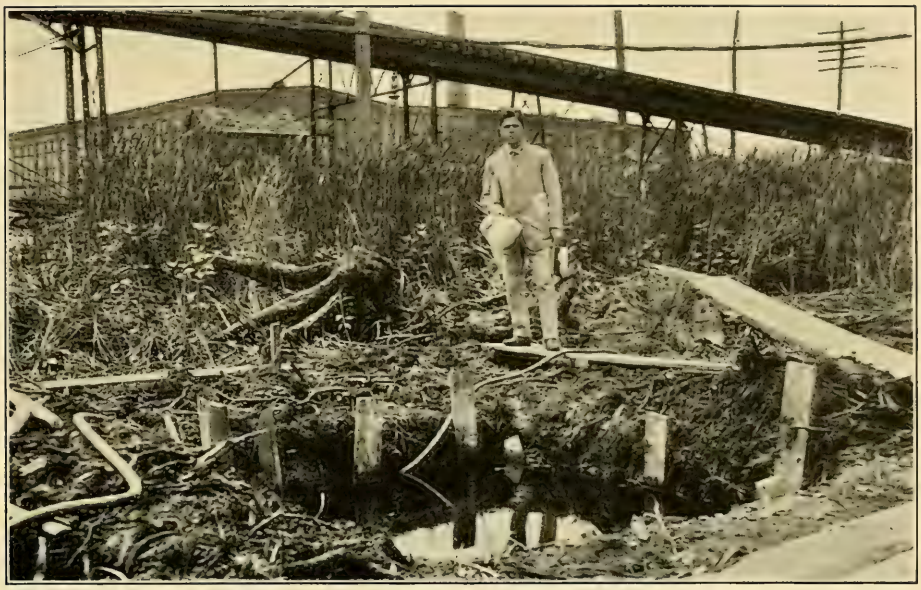

FIG. 3.
Holes in muck of Hackensack Marsh from which stumps of white cedar in the background have been extracted, July 15, 1916. J. W. H.

FIG. 4.
Tall Cattails, *Typha latifolia*, with Mullein, *Verbascum Thapsus*, Hackensack Marsh, July 15, 1916. J. W. H.

daily the surface of the salt marsh is partly or wholly flooded with salt or brackish water.*

The outer margin of the salt marsh, where it touches the open lagoon, or the tidal thoroughfare, is fringed with a broader, or a narrower, strip of the tall salt grass, *Spartina glabra* var. *pilosa*. Back of this strip, whose width depends on the slope and the height to which the tide rises, we find the rush salt grass, *Spartina patens*, which grows at a slightly higher tidal level. Then come the extensive areas of the black grass, *Juncus Gerardi*, upon which, in part, the economic value of the marsh depends. Sometimes there are extensive areas covered with lesser salt grass, *Distichlis spicata*. The samphires, *Salicornia ambigua*, *S. europæa*, grow in pure associations, sometimes mingling with the lesser salt grass, *Distichlis spicata*. The sea lavender, *Limonium carolinianum*, is also found with the samphires, as also *Suæda maritima* and *Atriplex patula*. Finally fresh-water conditions begin to prevail and typical fen vegetation becomes dominant the marsh surface over.

Fen Formation.—The acquaintance of the writer with the vegetation of the Hackensack fenland is based on numerous trips across it by railroad between Newark and Jersey City, Hoboken and Rutherford, by several trunk lines, viz., the Pennsylvania, Baltimore and Ohio, Delaware, Lackawanna and Western, and the Erie at all seasons of the year. A detailed study of the marsh was made in company with Vincent G. Burns, who continued its study by a notable collection of plants during several growing seasons. The three most prominent associations of the fen formation are characterized by the dominance of one of three plants, *Phragmites communis*, *Typha latifolia* (inland), *T. angustifolia* (influenced by brackish water), and *Zizania palustris*.

*Phragmites communis* covers extensive areas and is impressive at all seasons of the year (Figs. 5, 6). In the spring its fresh, light greens are noticeable; in autumn and early winter its purplish plumes of spikelets bending gracefully with the wind are striking. The movement of the leaves by a turning of the sheaths through an angle of 180 degrees brings them all on to the leeward side of the stem, in the direction in which the wind blows. Where sand has been washed into the marsh the reed forms long running rhizomes, which, growing up out of the muck, stretch across the sand as leafy stolons, a measured distance, in one case, of 5.8 meters. Green, leafy, erect shoots

* *Harshberger, J. W.:* The Vegetation of the Salt Marshes and of the Salt and Fresh Water Ponds of the Northern Coast of New Jersey. Proc. Acad. Nat. Sci. of Phila., 1909: 373–400.

are produced all along this rhizome, which reaches the thickness of a lead-pencil.

Recently Harper,* in some dynamic studies of Long Island vegetation, has estimated that one acre of *Phragmites communis* about 10 feet tall, with 77 stems per square yard, or 372,680 stems per acre, on September 19th produced 48,400 pounds of fresh material, 24,000 pounds of air-dried material, and 1585 pounds of ash. In dry weight of the marsh plants *Phragmites* leads by a large margin.

Elsewhere the cattails, *Typha angustifolia* and *T. latifolia*, are supreme, the former growing most commonly where it is influenced by an occasional inundation of salt water, while the latter is more strictly confined to fresh-water conditions. These two plants compete with the reed grass, *Phragmites*, in the occupation of the marshland. It would be hard to say, without experimental data, just what conditions determine the success of one or the other associations of plants. It may be edaphic, or it may be purely historic, reasons which determine the nice adjustment of conditions which permit the growth of the cattails to the exclusion of the reed, and vice versa. Harper (*loc. cit.*) has shown that an acre of *Typha latifolia*, with 1 per cent. of other plants standing 5 feet tall, with 30 stems per square yard, produced 31,460 pounds of fresh material, 12,100 of dried material, and 296 pounds of ash. *Typha angustifolia*, in a fresh marsh at the head of a brackish marsh, growing 9 feet tall with 61 stems per square yard, all sterile, yielded 53,240 pounds of fresh substance, 15,443 pounds of dried material, and 843 pounds of ash. All these estimates are from plants growing in marshes on Long Island, east of New York City, and, therefore, the figures probably stand good for similar sized areas on the Hackensack marsh.

The wild rice, *Zizania palustris*, is found most usually in the deeper water along some stream or river controlled by fresh water, where it forms associations of considerable width and size. In early spring, as its shoots appear above the muck surface, they are light green, and as summer advances the plants sometimes grow to be 10 feet tall. In August, when the wild-rice fruits are ripe, the marsh is lively with various birds that feed upon the wild rice. Such are the reed birds (bobolinks) and Sora rail, also large flocks of red-winged blackbirds, while in July, August, and September swallows are by far the

* The Plant World, 21: 38–46.

FIG. 5.

Society of Reed Grass, *Phragmites communis*, in middle ground of picture, and *Hibiscus Moscheutos* in flower in the foreground. Typical expanse of Hackensack Marsh near the Penna. R. R. Trestle, August 31, 1916. V. G. B.

FIG. 6.

Reed Grass, *Phragmites communis*, near the Hackensack River Bridge on the Harrison Turnpike, August 25, 1916. V. G. B.

FIG. 7.

Reed Grass, *Phragmites communis*, surrounding a low tree of Wild Black Cherry, *Prunus serotina*, near a Branch of Sawmill Creek, August 15, 1916. V. G. B.

most abundant birds of the meadow and use the reeds as dormitories. These birds perch in long lines on roadside telegraph wires above the marsh.*

Associated with these three plants, varying here and there in abundance, is the rose-mallow, *Hibiscus Moscheutos*, which glorifies the grassy stretches in August with numerous large rose-pink to white flowers. The arrow-leaf, *Sagittaria latifolia*, is found in standing water everywhere in the area. *Scirpus cyperinus*, *Spartina cynosuroides* (Fig. 10), are abundantly associated with the taller plants, forming the same layer of growth. The Turk's-cap lily, *Lilium superbum*, noted by me in full flower on August 6, 1916, is not uncommon. The three-seeded mercury, *Acalypha virginica*, is a rare fen species, but *Impatiens biflora*, the spotted touch-me-not, is extremely common in shady places. Three members of the carrot family, UMBELLIFERÆ, seem at home in the wet muck, viz., the water hemlock, *Cicuta maculata*, *Sium cicutæfolium*, and the low *Ptilimnium capillaceum*, which seems to increase as the brackish part of the marsh is approached. The Indian hemp, *Apocynum cannabinum*, is common, along with the showy swamp milkweed, *Asclepias incarnata* var. *pulchra*, visited by thousands of butterflies. The hedge bindweed, *Convolvulus sepium*, climbs up the tall grasses and cattails, while the dodder, *Cuscuta compacta*, is parasitic on goldenrod. Two species of *Lycopus* (see list) are found in the marsh. The Hackensack fen is brightened in early September by the flowers of *Bidens lævis*, massed in bright golden patches, which, with the whites and pinks of the rose-mallow, *Hibiscus Moscheutos* (Fig. 9), and other plants with conspicuous colors (asters, goldenrod), turn the fenland into a wonderful flower-garden.

The ferns of the marshy swales are *Osmunda regalis* (Fig. 11), *Onoclea sensibilis*, *Aspidium Thelypteris*. The water of some of the drainage ditches is covered with floating duckweed, *Lemna minor* (Fig. 8), and several species of *Potamogeton* occur. The bladderwort, *Utricularia intermedia* (Fig. 12), filled a ditch with its bright yellow flowers on July 15, 1916.

Other taller grasses associated with the dominant ones are *Calamagrostis canadensis*, *Echinochloa Walteri*, and *Spartina cynosuroides* (in fresh-water marsh) (Fig. 10).

CARR FORMATION.—The woody plants of the Hackensack fenland are

* *McAtee, W. L.:* Three Important Duck Foods. Circular No. 81, Bureau of Biological Survey, Sept. 9, 1911: Five Important Wild Duck Foods, Bulletin 58, U. S. Dept. of Agri.; Eleven Important Wild Duck Foods, Bulletin 205, U. S. Dept. of Agri., May 20, 1915.

either isolated individuals, or else they are found in associations forming the marsh thickets, or carr. *Quercus bicolor*, the swamp white oak, is found in low swales bordering the fens, along with *Amelanchier oblongifolia*, *Pyrus arbutifolia*, *Rosa carolina*, *Sambucus canadensis*, and *Acer rubrum*. The wild cherry, *Prunus serotina*, grows entirely isolated in a *Phragmites* marsh, or it enters the thickets as a rather prominent element (Fig. 7). The Virginia creeper, *Psedera quinquefolia*, and pigeon grape, *Vitis æstivalis*, grow in the carr and clamber over the trees and shrubs, binding them together. The white ash, *Fraxinus americana*, is an element of moist thickets, as also the black haw, *Viburnum prunifolium*. These isolated shrubs and trees and the above thickets break the monotonous sky-line. In one or two places along the eastern edge of the marsh the thicket interspaces are invaded by trees and shrubs, so that in a few years, assisted by the artificial drainage which is taking place, the thicket formation will be extended so as to cover large areas of the open fen.

Vegetation of Snake Hills.—One other unit of vegetation should be mentioned in closing this account of the formation of the Hackensack Marsh. As previously mentioned by the junior author, Burns, there are two basaltic outcrops, represented by Snake Hill and Little Snake Hill, which support a dry upland vegetation. As they form conspicuous landmarks in the center of the marsh, actually dividing it into an upper and a lower portion, a brief account of the vegetation is appropriate. The trees of the Snake Hills are *Juglans cinerea*, *Betula lutea*, *Quercus Prinus* (abundant), *Celtis occidentalis* in rocky areas, *Sassafras variifolium*, *Hamamelis virginiana*, *Liquidambar Styraciflua*, *Acer saccharum*, *Cornus paniculata*, *Viburnum pubescens*, while the late blueberry, *Vaccinium vacillans*, forms the common undergrowth layer on these rocky hills. The herbaceous plants of such rocky hills are given in the list of plants collected by Vincent G. Burns and need not be mentioned here.

## THE FLORA (V. G. B.)

In view of the fact that the difference between low and high tide levels in the Hackensack River is only 2 or 3 feet, and as one goes up the river the water becomes less salt, it would be expected that the flora would change from a typical salt marsh near Newark Bay, at the river mouth, to a brackish flora in the center of the valley, and finally to a fresh-water flora in the northern part. Also it would be expected that, as one went back from the river on

FIG. 8.
A stagnant pool covered with Duckweed, *Lemna minor*, and surrounded with Cattails, *Typha*, near the Belleville Turnpike, August 18, 1916. V. G. B.

FIG. 9.
Marsh Rose Mallow, *Hibiscus Moscheutos*, not far from Schuyler's Corner and the Belleville Turnpike, August 15, 1916. V. G. B.

FIG. 10.
*Spartina cynosuroides* in flower near the Harrison Turnpike, September 3, 1917. V. G. B.

either side the flora would become less and less that of the typical salt marsh. In a general way these conditions prevail. For example, *Spartina glabra* var. *pilosa* is very common along the lower banks of the Hackensack, but it is entirely absent above Sawmill Creek. Similarly, *Juncus Gerardi* and *Spartina patens*, typical salt-marsh plants, are found near Newark Bay and on the flats around Penhorn Creek, but there is not a sign of these plants in the upper part of the valley. In the northern part of the Hackensack region there are acid swamps, characterized by such oxylophytes as *Vaccinium corymbosum*, *Rhododendron viscosum*, *Acer rubrum*, and *Clethra alnifolia*. In the southern part acid swamps are absent, and it is interesting to note that the transition area between acid swamps and alkaline salt marsh is easily demarcated. In fact, one can draw an exact line of tension between salt and fresh-water marsh floras, since the latter is distinguished from the former by the absence of the characteristic grasses and grass-like plants. The following is a list of the plants collected and identified, with a note of the habitat and other matters of interest:

## LIST OF PLANTS

### DIVISION II.—PTERIDOPHYTA

#### Polypodiaceae

*Aspidium Thelypteris* (L.) Sw. (Wood Fern).

This fern is quite common throughout the marshes in shaded brackish situations.

*Onoclea sensibilis* L. (Sensitive Fern).

Moist brackish meadows and along ditches.

*Osmunda regalis* L. (Flowering Fern) (Fig. 11).

In ditches along Belleville Road.

#### Equisetaceae

*Equisetum arvense* L. (Common Horsetail).

Roadsides and gravelly banks. This plant seems to delight in soil which lacks humus.

#### Lycopodiaceae

*Lycopodium alopecuroides* L.

Swamps near Moonachie.

## DIVISION III.—SPERMATOPHYTA

### Class 1.—Monocotyledoneae

#### Typhaceae

*Typha angustifolia* L. (Cattail).

One of the most common plants of the marshes, growing chiefly in brackish habitats.

*Typha latifolia* L. (Common Cattail) (Figs. 4, 8).

Growing chiefly in the inner fresh-water parts of the Hackensack fen country.

#### Alismaceae

*Alisma Plantago-aquatica* L.

Common in shallow ponds and ditches.

*Sagittaria latifolia* Willd.

Found in ditches and standing water everywhere on the marshes.

#### Graminaceae

*Andropogon furcatus* Muhl.

Dry banks on Little Snake Hill.

*Andropogon scoparius* Michx. (Beard Grass).

Dry, rocky ground on Little Snake Hill and elsewhere.

*Avena sativa* L. (Oats).

Roadsides.

*Calamagrostis canadensis* (Michx.) Beauv. (Blue-joint Grass).

Rocky thickets bordering the marsh around Little Snake Hill.

*Dactylis glomerata* L. (Orchard Grass).

Fields and roadsides.

*Digitaria sanguinalis* L. Scop. (Crab Grass).

Common along roadsides and embankments.

*Distichlis spicata* L. Greene (Spike Grass).

Common typical salt marshes.

*Echinochloa Walteri* (Pursh) Nash.

Brackish meadows and marsh borders.

*Eleusine indica* Gaertn. (Goose Grass).

Railroad embankments.

*Eragrostis pilosa* (L.) Beauv.

Railroad embankments. Common.

*Hystrix patula* Moench (Bottle-brush grass).

Moist thickets on Snake Hill.

*Leersia virginica* Willd. (White Grass).

Wet woods on Snake Hill.

FIG. 11.
Clump of Royal Fern, *Osmunda regalis*, in ditch along Belleville Road, across Hackensack Marsh, July 15, 1916. J. W. H.

FIG. 12.
Shallow channel filled with Bladderwort, *Utricularia intermedia*, in flower, and Great Water Dock, *Rumex Britannica*, along its edge, Hackensack Marsh, July 15, 1916. J. W. H.

*Panicum capillare* L. (Old-witch Grass).

Common on sandy ground and gravelly embankments.

*Panicum clandestinum* L.

On Snake Hill and adjacent fields.

*Panicum dichotomiflorum* Michx.

Common on railroad embankments and dry parts of the marshes.

*Panicum huachucae* Ash.

Open fields on Snake Hill.

*Panicum virgatum* L. (Switch Grass).

Common along Sawmill Creek and other dry parts of the true salt marshes.

*Phragmites communis* Trin. (Figs. 5, 6).

This is perhaps the most common plant on the marshes. It grows everywhere, in both brackish and fresh parts, spreading freely by long creeping root-stocks and attaining a height of 10 feet. The ribbon-shaped green leaves of this plant give the marsh its light greenish hue of midsummer.

*Setaria glauca* (L.) Beauv. (Foxtail Grass).

Open ground in the less brackish parts of the marsh.

*Sorghastrum nutans* (L.) Nash (Indian Grass).

Dry gravelly banks of Little Snake Hill.

*Spartina cynosuroides* (L.) Roth. (Salt Reed Grass) (Fig. 10).

This quite common species grows on the higher parts of the marsh well back from the river.

*Spartina glabra* var. *pilosa* Merr. (Salt-marsh Grass).

Along the Hackensack River, from Sawmill Creek southward.

*Spartina patens* (Ait) Muhl.

Occurs on the salt-marsh flats in great abundance, usually well back from the river.

*Spartina patens* var. *juncea* (Michx) Hitchc.

In brackish habitats and farther inland from the river than the species.

*Zizania palustris* L. (Indian Rice, Water Oats).

Mostly occurs along ditch borders in the northeastern corner of the valley. A gigantic grass with great stout culms and tall panicles, sometimes exceeding 10 feet. The natives call it "Bobolink Seed," because of the fondness of these birds for the grain.

CYPERACEAE

*Cyperus filiculmis* Vahl.

Dry sterile soil on Snake Hill.

*Cyperus Nuttallii* Eddy.

Common in brackish soil.

*Cyperus strigosus* L.
Damp soil along ditches, etc.
*Scirpus americanus* Pers. (Three Square).
Salt-marsh borders. At many places on the higher parts of the marshes this tall-growing sedge is cut and used for hay.
*Scirpus cyperinus* (L.) Kunth (Wool Grass).
Wet meadows and thickets bordering the marshes.
*Stenophyllus capillaris* (L.) Britton.
Dry sterile soil on Snake Hill.

ARACEAE
*Peltandra virginica* (L.) Kunth (Green Arrow Arum).
Shallow water of ditches.

LEMNACEAE
*Lemna minor* L. (Duck-weed) (Fig. 8).
On the surfaces of stagnant water in pools and ditches all over the marsh.

COMMELINACEAE
*Commelina communis* L. (Day-flower).
A frequent plant in low swales and ditches.

JUNCACEAE
*Juncus canadensis* J. Gay.
Occurring everywhere on the typical salt brackish marsh.
*Juncus Gerardi* Loisel (Black Grass).
This is one of the most typical salt-marsh plants and is found on all the true salt-marsh flats.
*Juncus tenuis* Willd.
Very common along roadsides and in dry fields.

LILIACEAE
*Lilium superbum* L. (Wild Yellow Lily).
Wet meadows and bogs near the marsh borders.
*Lilium philadelphicum* L. (Wood Lily).
Rare. Dry ground near Snake Hill.
*Smilacina racemosa* (L.) Desf. (False Spikenard).
Moist woods and banks on Snake Hill and Little Snake Hill.
*Smilax rotundifolia* L. (Common Green Briar).
Moist thickets near Snake Hill.

ORCHIDACEAE

*Calopogon pulchellus* (Sw.) R.Br.
Rich open grounds near Moonachie.
*Habenaria ciliaris* (L.) R.Br. (Yellow-fringed Orchid).
Meadows near Moonachie.
*Pogonia ophioglossoides* (L.) Ker.
Boggy meadows near Moonachie.

## CLASS 2.—DICOTYLEDONEAE

SALICACEAE

*Populus grandidentata* Michx.
Rich thickets bordering the marshes.
*Salix babylonica* L. (Weeping Willow).
A few isolated trees on the marsh near Secaucus.
*Salix cordata* Muhl.
Wet places along Belleville Turnpike.
*Salix nigra* Marsh (Black Willow).
Wet banks near Snake Hill.

MYRICACEAE

*Myrica carolinensis* Mill (Bayberry).
Gravelly railroad embankments.

JUGLANDACEAE

*Juglans cinerea* L. (Butternut).
On Snake Hill in open woods.

BETULACEAE

*Betula lenta* L. (Cherry Birch).
Open woods on Snake Hill.
*Betula populifolia* Marsh (Gray Birch).
Sterile soil along the Belleville Turnpike.

FAGACEAE

*Quercus alba* L. (White Oak).
Dryish fields near marsh borders.
*Quercus bicolor* Willd. (Swamp White Oak).
Low swales bordering marsh.
*Quercus Prinus* L. (Chestnut Oak).
Rocky banks on Snake Hill and Little Snake Hill.

*Quercus velutina* Lam. (Black Oak).
Dry gravelly embankments.

URTICACEAE

*Celtis occidentalis* L. (Sugarberry).
Rocky woods on Snake Hill.
*Humulus Lupulus* L. (Common Hop).
Moist banks and rubbish heaps in the northeast section of the marsh.
*Ulmus americana* L. (American Elm).
Moist banks along Snake Hill.

POLYGONACEAE

*Polygonum arifolium* L. (Halberd leaved Tear-thumb).
Common in low grounds, clambering over other plants.
*Polygonum aviculare* L.
Common everywhere in waste places and on railroad embankments.
*Polygonum Convolvulus* L. (Black Bindweed).
Railroad embankments and waste places.
*Polygonum Hydropiper* L. (Common Smartweed).
Moist grounds.
*Polygonum hydropiperoides* Michx. (Mild Water Pepper).
Wet places and shallow water in brackish habitats.
*Polygonum lapathifolium* L.
Common on moist banks and on brackish meadows.
*Polygonum orientale* L. (Prince's Feather).
Moist ditches and waste ground.
*Polygonum pennsylvanicum* L.
Common in wet open meadows.
*Polygonum Persicaria* L. (Lady's Thumb).
Common moist places.
*Polygonum sagittatum* L. (Arrow-leaved Tear Thumb).
Clambering over other plants in low swales.
*Polygonum scandens* L. (Climbing False Buckwheat).
Clambering on Typha and Phragmites.
*Polygonum virginianum* L.
Moist woods on Snake Hill.
*Rumex Acetosella* L. (Sheep Sorrel).
A common weed everywhere on the dry places.
*Rumex Britannica* L. (Great Water Dock) (Fig. 12).
A tall, stout herb, growing in great abundance everywhere on the brackish flats.

CHENOPODIACEAE

*Atriplex patula* L.
Brackish flats on the Hackensack River banks.

*Atriplex patula* var. *hastata* (L.) Gray.
Hackensack River banks and inland.

*Chenopodium album* L. (Pigweed).
Everywhere on drier parts.

*Chenopodium ambrosioides* L. (Mexican Tea).
Waste places and brackish meadows.

AMARANTHACEAE

*Acnida cannabina* L.
A very tall, tree-like herb growing throughout the marshes in brackish stations.

*Amaranthus retroflexus* L. (Pigweed).
Roadsides and cultivated grounds.

PHYTOLACCACEAE

*Phytolacca decandra* L. (Pokeweed).
Gravel of railroad embankments.

CARYOPHYLLACEAE

*Saponaria officinalis* L. (Bouncing Bet).
Very common along roadsides, embankments, and in waste grounds.

*Silene stellata* (L.) Ait. f. (Starry Campion).
Woody banks on Snake Hill.

RANUNCULACEAE

*Thalictrum polygamum* Muhl.
Wet meadows near Belleville Turnpike.

LAURACEAE

*Sassafras variifolium* (Salisb.) Ktze.
Open woods on Snake Hill.

CRUCIFERAE

*Lepidium virginicum* L. (Wild Pepper Grass).
Common in waste places.

*Sisymbrium altissimum* L. (Tumble Mustard).
Roadsides and waste places.

SAXIFRAGACEAE

*Parnassia caroliniana* Michx.
Swamps near Moonachie.

HAMAMELIDACEAE

*Hamamelis virginiana* L. (Witch-hazel).
Open woods on Snake Hill.
*Liquidambar Styraciflua* L. (Sweet Gum).
Open woods on Snake Hill.

ROSACEAE

*Amelanchier oblongifolia* (T. & G.) Roem.
Moist thickets near Belleville Turnpike.
*Potentilla canadensis* var. *simplex* (Michx.) T. & G.
Dry gravelly soil along embankments.
*Potentilla monspeliensis* L.
Dry banks. Common.
*Potentilla primula* Poir.
Common on dry open soil.
*Prunus serotina* Ehrh. (Wild Cherry) (Figs. 7, 13).
Very common in every section of the marshes. Especially frequent along the banks of Sawmill Creek, where it is the only tree.
*Pyrus arbutifolia* (L.) L. f. (Chokeberry).
Swamps and low thickets.
*Pyrus melanocarpa* (Michx.) Willd.
Moist woods.
*Rosa humilis* Marsh.
Dry embankments along the Belleville Turnpike.
*Sanguisorba canadensis* L. (Canadian Burnet).
Bogs and wet swales. Common.
*Spiraea tomentosa* L. (Hardhack).
Wet banks along Belleville Turnpike.

LEGUMINOSAE

*Desmodium canadense* L. (Tick Trefoil).
Wet meadows and swales.
*Gleditsia triacanthos* L. (Honey Locust).
Railroad embankments, Delaware, Lackawanna & Western R. R., near Hackensack River.
*Lespedeza frutescens* L. (Bush Clover).
Sterile soil on Little Snake Hill.

FIG. 13.
Wild Black Cherry, *Prunus serotina*, forming with other shrubs a Marsh Thicket (Carr) on the bank of Sawmill Creek, August 15, 1916. V. G. B.

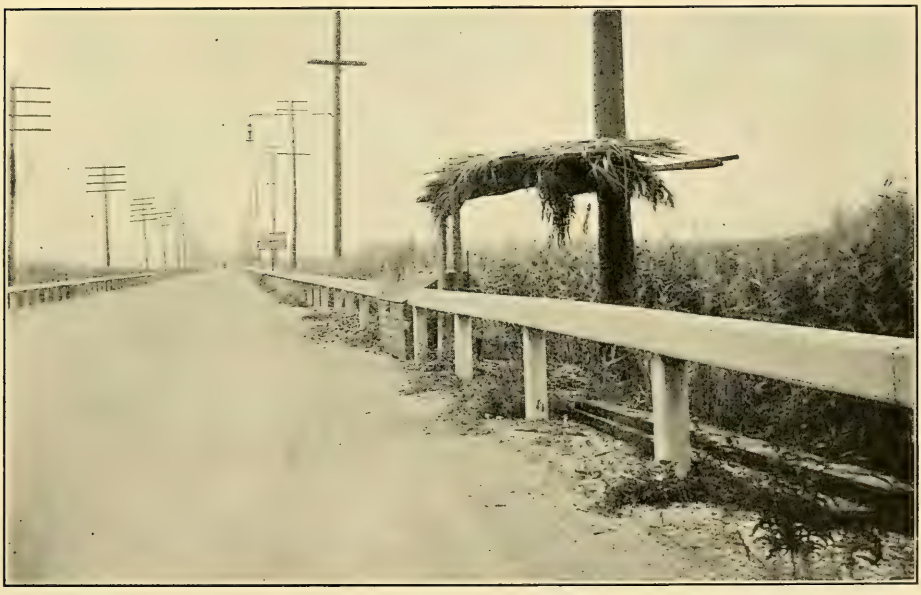

FIG. 14.
Shelter constructed of uprights and thatched with cut stalks of Reed, *Phragmites communis*, along Belleville Road, Hackensack Marsh, July 15, 1916. J. W. H.

*Lespedeza hirta* (L.) Hornem.
Sterile soil on Little Snake Hill.
*Medicago sativa* L. (Alfalfa).
Roadsides and railroad embankments.
*Melilotus alba* Desr. (White Melilot).
Roadsides. Common.
*Melilotus officinalis* (L.) Lam. (Yellow Melilot).
Roadsides. Common.
*Trifolium arvense* L. (Rabbitfoot Clover).
Dry gravelly roadsides.
*Trifolium pratense* L. (Red Clover).
Common in fields.
*Trifolium procumbens* L. (Low Hop Clover).
Sandy grounds and roadsides.
*Trifolium repens* L. (White Clover).
Common by roadsides and paths.

SIMARUBACEAE

*Ailanthus glandulosa* Desf. (Tree of Heaven).
Thickets along banks near Arlington.

EUPHORBIACEAE

*Acalypha virginica* L. (Three-seeded Mercury).
Belleville Turnpike Embankment. Rare.
*Euphorbia maculata* L. (Milk Purslane).
Makes great mats of dull red foliage on gravelly railroad embankments.
*Euphorbia Preslii* Guss.
Belleville Turnpike embankment. Rare.

ANACARDIACEAE

*Rhus glabra* L. (Smooth Sumac).
Dry banks and meadows. Common.
*Rhus Toxicodendron* L. (Poison Ivy).
Very common over rock and along embankments.
*Rhus typhina* L. (Staghorn Sumac).
Little Snake Hill.

CELASTRACEAE

*Celastrus scandens* L. (Climbing Bitter Sweet).
Common on rocky banks of Little Snake Hill.

ACERACEAE

*Acer rubrum* L. (Swamp Maple).
Very common in the acid swamps of the southern part of the valley.
*Acer saccharinum* L. (Silver Maple).
Rocky banks of Snake Hill.
*Acer saccharum* Marsh (Sugar Maple).
Woods all over Snake Hill.

BALSAMINACEAE

*Impatiens biflora* Walt. (Spotted Touch-me-not).
Abundant in shady moist places.

VITACEAE

*Psedera quinquefolia* L. Greene (Virginia Creeper).
Trailing over pipe lines which cross the marshes.
*Vitis aestivalis* Michx. (Pigeon Grape).
Thickets on the steep western slopes of Snake Hill.

MALVACEAE

*Hibiscus Moscheutos* L. (Swamp Rose Mallow) (Figs. 5, 9).
On brackish flats, borders of thickets, in shady moist copses, or out in the meadow. This is one of the most beautiful and striking plants in our wild flora. In August the marsh looks like a vast flower garden, for many areas are colored white and pink by the profusion of the large flowers.

ONAGRACEAE

*Epilobium angustifolium* L. (Fire-weed).
Gravelly embankments and roadsides.
*Epilobium hirsutum* L.
Rather rare on the marsh, having been seen by the writer only in an isolated spot near the Public Service Works.
*Ludvigia alternifolia* L. (Seed-box).
Banks of Little Snake Hill.
*Oenothera biennis* L. (Evening Primrose).
Very common in waste places.

UMBELLIFERAE

*Cicuta maculata* L. (Water Hemlock).
Common in wet meadows.
*Daucus Carota* L. (Wild Carrot).
Common along roadsides.

*Ptilimnium capillaceum* (Michx.) Raf.
Brackish marshland everywhere.
*Sium cicutæfolium* Schrank.
Common in moist situations.

CORNACEAE

*Cornus Amomum* Hill (Kinnikinnick).
Rare. One station only, along Belleville Turnpike, near Erie Railroad.
*Cornus paniculata* L'Her.
Thicket on summit of Snake Hill.

ERICACEAE

*Clethra alnifolia* L. (Sweet Pepperbush).
Between Secaucus and the Susquehanna Railroad.
*Rhododendron viscosum* (L.) Torr (Clammy Azalea).
In the swamp between Secaucus and the Susquehanna Railroad.
*Vaccinium corymbosum* L. (High-bush Blueberry).
In the swamp between Secaucus and the Susquehanna Railroad.
*Vaccinium vacillans* Kalm (Late Low Blueberry).
Common all over Snake Hill.

PRIMULACEAE

*Samolus floribundus* H. B. K. (Water Pimpernel).
Wet low places in the northern marshes.

OLEACEAE

*Fraxinus americana* L. (White Ash).
Moist thickets.

GENTIANACEAE

*Menyanthes trifoliata* L. (Buckbean).
Bogs and shallow water near Moonachie.
*Sabatia dodecandra* (L.) B. S. P.
Swamp near Moonachie.
*Sabatia stellaris* Pursh.
Salt marshes and around Little Snake Hill and Snake Hill.

APOCYNACEAE

*Apocynum cannabinum* L. (Indian Hemp).
Wet copses near the Belleville Turnpike and sandy banks elsewhere over the marsh.

*Asclepias incarnata* var. *pulchra* (Ehrh.) Pers. (Swamp Milkweed).
Common in swampy situations.

CONVOLVULACEAE

*Convolvulus arvensis* L. (Field Bindweed).
Waste places and railroad embankments.
*Convolvulus sepium* L. (Hedge Bindweed).
Clambering over tall herbs in marsh thickets.
*Cuscuta compacta* Juss. (Dodder).
Clambering over Goldenrods in moist thickets.
*Cuscuta Gronovii* Willd. (Dodder).
In wet shady copses, climbing on other plants.

BORAGINACEAE

*Echium vulgare* L. (Viper's Bugloss).
Common along roadsides.

VERBENACEAE

*Verbena hastata* L. (Blue Vervain).
Damp banks and roadsides.

LABIATAE

*Collinsonia canadensis* L. (Horse Balm).
Rich moist woods on western slopes of Snake Hill.
*Lycopus americanus* Muhl.
Damp soil near embankments.
*Lycopus virginicus* L. (Bugle Weed).
Rich moist grounds.
*Nepeta Cataria* L. (Catnip).
In gravel near the Harrison Turnpike.
*Pycnanthemum virginianum* (L.) Durand and Jackson.
Dry open hillsides of Little Snake Hill.
*Teucrium canadense* var. *littorale* (Bicknell) Fernald.
Common marsh thickets and low grounds.

SOLANACEAE

*Datura Stramonium* L. (Jimson Weed).
Common on rubbish heaps and gravel embankments.
*Solanum Dulcamara* L. (Bittersweet).
Northern part of the Hackensack region.

SCROPHULARIACEAE

*Gerardia purpurea* L. (Purple Gerardia).
Low marshland around Little Snake Hill.

*Linaria vulgaris* Hill (Toadflax).
Roadsides and fields.

*Scrophularia leporella* Bicknell.
Rich open woods on Snake Hill.

*Verbascum Blattaria* var. *albiflorum* Ktze. (Moth Mullein).
Common along roadsides.

*Verbascum Thapsus* L. (Comon Mullein).
Fields and gravelly banks.

LENTIBULARIACEAE

*Utricularia intermedia* Hayne (Bladderwort) (Fig. 12).
In a low ditch by the Belleville Turnpike.

PLANTAGINACEAE

*Plantago lanceolata* L. (English Plantain).
Common along roadsides and in fields.

*Plantago major* L. (Common Plantain).
Very common in all waste places.

CAPRIFOLIACEAE

*Sambucus canadensis* L. (Common Elder).
Very common in the drier parts of the marsh.

*Triosteum perfoliatum* L. (Wild Coffee).
Open fields on Snake Hill.

*Viburnum prunifolium* L. (Black Haw).
Moist thickets near Schuyler's Corner.

*Viburnum pubescens* (Ait.) Pursh. (Downy Arrow-wood).
Rocky banks of Little Snake Hill.

CUCURBITACEAE

*Sicyos angulatus* L. (One-seeded Bur Cucumber).
Clambering over low herbs in the northeastern corner of the valley.

LOBELIACEAE

*Lobelia siphilitica* L. (Great Lobelia).
Open meadow near Schuyler's Corner.

COMPOSITAE

*Achillea Millefolium* L. (Yarrow).
Very common along roadsides.

*Ambrosia artemisiifolia* L. (Ragweed).
Very common along roadsides.

*Ambrosia trifida* L. (Great Ragweed).
Forms thick green patches along marsh borders and ditches.

*Arctium minus* Bernh.

*Aster paniculatus* Lam.
Hackensack marsh.

*Aster paniculatus* Lam. var. *bellidiflorus* (Willd.) Burgess.
Hackensack marsh.

*Aster Tradescanti* L.

*Bidens frondosa* L. (Beggar-ticks).
Common in wet grounds.

*Bidens laevis* (L.) B. S. P.
In brackish marsh over the valley. In early September this plant makes great golden patches on the marsh.

*Bidens trichosperma* (Michx.) Britton.
Marshes and ditches in the north.

*Chrysanthemum leucanthemum* L. (White Daisy).
Common along roadsides.

*Cichorium Intybus* L. (Chicory).
Roadsides and banks.

*Cirsium lanceolatum* (L.) Hill (Bull Thistle).
Gravelly embankments and roadsides.

*Erechtites hieracifolia* (L.) Raf. (Fireweed).
Moist meadows. Common.

*Eupatorium perfoliatum* L. (Boneset).
Common in low copses.

*Eupatorium purpureum* L. (Joe-Pye Weed).
Low moist meadows. Common.

*Eupatorium sessilifolium* L. (Upland Boneset).
Meadows on Snake Hill.

*Galinsoga parviflora* Cav.
Railroad embankments.

*Helianthus annuus* L. (Sunflower).
Waste ground along ditches near the Susquehanna Railroad in the northeastern part of the valley.

*Helianthus divaricatus* L.
Dry copses and banks.

*Helianthus giganteus* L.
Low thickets and marsh. Common.
*Helianthus strumosus* L.
Dry banks.
*Iva oraria* Bartlett.
A rather common shrub in brackish places.
*Lactuca scariola* L. (Prickly Lettuce).
Very common along roadsides and railroad embankments.
*Lactuca spicata* (Lam.) Hitchc.
Low grounds. Common.
*Pluchea camphorata* (L.) D.C. (Salt Marsh Fleabane).
Common on the typical salt marsh.
*Prenanthes alba* L. (Rattlesnake-root).
Prominent in low marshy swales.
*Prenanthes trifoliolata* (Cass) Fernald (Gall-of-the-Earth).
Thickets on Snake Hill.
*Rudbeckia laciniata* L. (Cone flower).
Low moist meadows. Rather uncommon.
*Solidago altissima* L.
A common plant in rich open soil.
*Solidago bicolor* L. (White-flowered Golden Rod).
Common on dry soil on Snake Hill and Little Snake Hill.
*Solidago canadensis* L. (Common Golden Rod).
In thickets and rich open soil.
*Solidago graminifolia* (L.) Salisb.
Common in moist places.
*Solidago neglecta* Torr. & Gray.
Hackensack marsh.
*Solidago nemoralis* Ait.
Only on dry open places on Snake and Little Snake Hill.
*Solidago rigida* L.
Only on dry rock hillsides of Little Snake Hill.
*Solidago rugosa* Mill. (Rough-leaved Golden Rod).
Damp swales and wet thickets near roadsides.
*Solidago sempervirens* L. (Seaside Golden Rod).
Common on true salt marsh and on brackish flats back from the river.
*Solidago ulmifolia* Muhl.
Dry rocky woods on Snake Hill.
*Sonchus asper* (L.) Hill (Spring-leaved Sow-thistle).
Common along roadsides and embankments.

*Taraxacum officinale* Weber (Common Dandelion).
Abundant in waste places.
*Tussilago Farfara* L. (Coltsfoot).
On railroad embankments.
*Vernonia noveboracensis* Willd. (Ironweed).
In low swampy places. Common.
*Xanthium commune* Britt. (Cocklebur).
Shores of the Hackensack River.

## ADDITIONAL LIST OF HACKENSACK MARSH PLANTS (J. W. H.)

The following additional names have been taken from the "Catalogue of Plants found in New Jersey," by N. L. Britton, Final Report of the State Geologist, II, 1889:

### Polypodiaceae

*Woodwardia virginica* (L.) Smith (Chain Fern).

### Pinaceae

*Chamaecyparis thyoides* (L.) B. S. P. (White Cedar).
A few trees on the meadow near Newark, according to W. M. Wolfe.

### Najadaceae

*Potamogeton amplifolius* Tuck.
Hackensack River. Austin.
*Potamogeton pectinatus* L.
Hackensack River. Austin.
*Potamogeton Robbinsii* Oakes.
Hackensack River. Austin.

### Cyperaceae

*Carex trisperma* Dewey.
Secaucus. Leggett.
*Eleocharis olivacea* Torr.
Abundant on Hackensack marsh. Leggett.
*Eleocharis rostellata* Torr.
Abundant on Hackensack marsh. Leggett.
*Scirpus atrovirens* Muhl.
Common on Newark marsh. Leggett.
*Scleria triglomerata* Michx.
Newark marsh. Le Conte.

*Scleria verticillata* Muhl.
Hackensack marsh, 1863. J. F. Allen.

ARACEAE

*Calla palustris* L. (Water Arum).
Hackensack marsh. G. C. Woolson.

IRIDACEAE

*Heteranthera dubia* (Jacq.) Mac. M. (Mud Plantain).
Common along the Hackensack. Austin.
*Iris prismatica* Pursh. (Slender Blue Flag).
Hackensack marsh. Leggett.

ORCHIDACEAE

*Arethusa bulbosa* L.
Hackensack marsh. G. C. Woolson.

RANUNCULACEAE

*Coptis trifolia* (L.) Salisb. (Gold Thread).
Swamps along Hackensack River. G. C. Woolson.
*Ranunculus circinatus* Sibth.
Hackensack River. Austin.

LEGUMINOSAE

*Lathyrus palustris* L. var. *myrtifolius* (Muhl.) Gray.
Hackensack marsh. Leggett.

POLYGALACEAE

*Polygala cruciata* L.
Hackensack marsh. Leggett; Base of Snake Hill—N. L. Britton.

ACERACEAE

*Acer Negundo* L. (Box Elder).
Banks of Hackensack River west of Closter. Austin.

LYTHRACEAE

*Rotala ramosior* (L.) Koehne.
Hackensack marsh. Torrey Catalogue, 1819.
*Lythrum lineare* L. (Loosestrife).
Hackensack marsh. Leggett.

SCROPHULARIACEAE

*Limosella aquatica* L. var. *tenuifolia* (Wolf) Pers.
Hackensack River. Austin.

CAPRIFOLIACEAE

*Viburnum nudum* L.
Hackensack marsh. Leggett.

COMPOSITAE

*Liatris spicata* (L.) Willd.
Hackensack marsh. W. M. Wolfe.
*Solidago Elliottii* Torr. & Gray.
Hackensack marsh. Carey.

## ECONOMIC CONSIDERATIONS (V. G. B. AND J. W. H.)

Many experiments have been tried with *Phragmites* and other grasses and sedges which grow on the marsh with a view to their utilization in the making of cord and twine and in the making of paper pulp for the manufacturing of paper. Recently, however, a chemical process has been perfected by which marsh grasses and sedges become available for this purpose. Thousands of tons of marsh grasses and sedges are rotting each year on the Hackensack meadow that might be used profitably in the manufacture of paper, bagging, and roofing felts. Figure 14 illustrates the use of the marsh plants for shelter construction.

It is a well-known fact that reclaimed salt marsh makes good agricultural land. The reclaimed salt marshes of Holland, Belgium, and Nova Scotia are excellent examples of the value of such land. There the farmers have built dikes around the marshes to keep out the sea, and at intervals of several years the tide is allowed to flood limited portions of the polderland. This flooding replenishes the stock of certain salts in the soil without actually causing a return to the earlier conditions, if the flooding is properly regulated. According to W. F. Ganong, the same process has been used around the Bay of Fundy, where some of the largest and finest hay crops in eastern Canada have been produced.

These successes elsewhere suggest that the soil of the Hackensack marsh, if reclaimed, would become equally valuable. A system of dikes and sluice gates, perhaps, would be the most effective way of bringing about the desired

result. The fresh water, coming down the rivers and creeks from the interior, could pass out to sea through the sluiceways provided for this purpose, while the mechanism of the gate would prevent the salt water at high tide from flooding the agricultural land. Such a method would lower the water-table throughout the protected marsh, and by a system of drainage ditches the salts deposited originally by the sea water would be leached out of the soil by the rain water.

In the case of the Hackensack marsh, drainage ditches have helped considerably in the amelioration of the wild marsh conditions. This land has become extremely valuable for railroad terminals and factory sites, as much as $4000 per acre having been paid for some of it. The factory buildings have been built on foundations of concrete laid on the top of wooden piles, and the experience of the engineer in the rebuilding of the Venetian Campanile shows that such piles, if buried in the muck, may last many hundred years. The Campanile of San Marco was begun before the year 997 A.D. After its collapse, July 14, 1902, the foundations were studied by Sig. Giacomo Boni. The piles of white poplar were 9½ inches in diameter, driven into a bed of compact clay. When these were laid bare during the excavation preceding the reconstruction of the tower, the white poplar piles were found to be remarkably sound, retaining their color and fibrous character. This points to the conclusion that the men who build factories on timber piles in the Hackensack marshes, provided the piles are driven properly, need not fear a decay of the piles as long as the air is kept from them, which promotes the growth of bacteria and timber-destroying fungi. This fact is also emphasized by the discovery of undecayed stumps of white cedar trees in situ in certain parts of the marsh, as previously described. Such construction has been found to be costly on account of the depths to which the piles must be driven to give a secure foundation. Pile driving with a reclamation of the marsh land by scientific drainage will solve the difficulty, for D. C. Willoughby, a British engineer who has been working for years in building union railroad terminals on the Hackensack marsh, has come to the conclusion that before the marshes can be extensively used for building operations they must be thoroughly drained.

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